NOTICE!

ALL DRAWINGS
ARE LOCATED
AT THE END OF
THE DOCUMENT

FINAL

INTERIM REMEDIAL ACTION BENCH SCALE TREATABILITY STUDY REPORT VOLUME I

903 Pad, Mound, and
East Trenches Areas
(South Walnut Creek)

Operable Unit No 2

Environmental Restoration Program

May 22, 1992

U S DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

22558/R7 TS 05-18-92/RPT/2

FINAL

INTERIM REMEDIAL ACTION BENCH SCALE TREATABILITY STUDY REPORT VOLUME I

903 Pad, Mound, and
East Trenches Areas
(South Walnut Creek)

Operable Unit No 2

Environmental Restoration Program

May 22, 1992

U S DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

22558/R7 TS 05-18-92/RPT/2

ADMIN RECORD

REVIEWED FOR CLASSIFICATION/UCNI
By
Date

TABLE OF CONTENTS

VOLUME I

LIST OF TABLES

LIST OF FIGURES

LIST OF EXHIBITS

VOLUME VI

LABORATORY DATA REPORTS - VOLATILE ORGANIC COMPOUNDS

LIST OF ACRONYMS AND ABBREVIATIONS

1,1-DCE	Dichloroethylene
Al	Aluminum
ARARs	Applicable or Relevant and Appropriate Requirements
As	Arsenic
Ba	Barium
Ca	Calcium
Cd	Cadmium
Cr	Chromium
Cu	Copper
CPF	Coagulation/Precipitation/Filtration Sample
CWC	Composited Water Characterization Sample
DOE	Department of Energy
ER	Environmental Restoration
FSP	Field Sampling Plan (subelement of TSP)
GAC	Granular Activated Carbon
GAO	Granular Activated Carbon Sample
GC	Gas Chromatograph
IM/IRA	Interim Measure/Interim Remedial Action
IM/IRAP	Interim Measure/Interim Remedial Action Plan
K	Potassium
LAP	Laboratory Analysis Plan (subelement of TSP)
Mg	Magnesium
Mn	Manganese
Na	Sodium
ND	Nondetect
Ni	Nickel
OU2	Operable Unit Number 2
Pb	Lead
QC	Quality Control
RFP	Rocky Flats Plant
SAP	Sampling and Analysis Plan (subelement of TSP)
SOP	Standard Operating Procedures
TCE	Trichloroethene
Tl	Thallium
TOC	Total Organic Compounds
TSP	Treatability Study Plan
TSS	Total Suspended Solids
V	Vanadium
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compounds
Zn	Zinc

EXECUTIVE SUMMARY

The Rocky Flats Plant (RFP) is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver The Plant buildings are located within an area of approximately 400 acres, known as the RFP security area. The security area is surrounded by a buffer zone of approximately 6,150 acres

In the past, both storage and disposal of hazardous and radioactive wastes occurred at on-site locations Preliminary assessments conducted under Phase I of the Environmental Restoration (ER) Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination

The Department of Energy (DOE) wishes to pursue an interim remedial action for surface water at the 903 Pad, Mound, and East Trenches Area, now termed Operable Unit No 2 (OU2), at the RFP An Interim Measure/Interim Remedial Action (IM/IRA) Plan has been prepared to identify, screen, and evaluate appropriate interim remedial action alternatives, and select the preferred interim remedial action for the contaminated surface water The purpose of this project is to provide technical support to the IM/IRA in the form of bench-scale treatability tests

The OU2 Treatability Study Plan (EG&G 1990a), dated October 16, 1990, identified six individual bench-scale tests that were to be performed

- Granular activated carbon (GAC) for removal of volatile organic compounds
- GAC for removal of radionuclides
- Ion exchange for removal of radionuclides
- Adsorbents for removal of radionuclides
- Chemical coagulation/microfiltration for removal of radionuclides
- Coagulation/precipitation/filtration for removal of suspended solids

Due to the unavailability of radionuclide-contaminated surface waters at the site, only the GAC tests for removal of volatile organic compounds and coagulation/ precipitation/filtration tests for removal of suspended solids were performed This document reports on the results of those tests

The evaluation of GAC treatment for removal of volatile organic compounds was hampered by the low levels of volatile organic compounds (VOCs) present in the surface water tested and the limited volumes treated in the bench-scale GAC columns GAC was effective in removing 100 percent of the VOCs present in the surface water tested The third round of tests provided information on the breakthrough behavior However, the conclusions regarding breakthrough capacity are uncertain due to the test conditions

The evaluation of coagulation/precipitation/filtration for removal of suspended solids was hampered by the low levels of suspended solids present in the surface water tested The coagulants ferrous sulfate and aluminum sulfate were not as effective as ferric sulfate and ferric chloride, and pH adjustment did not improve performance Filtration without addition of coagulants was as effective as filtration after coagulant addition.

This report is organized into six volumes Volume I contains the report on the treatability testing conducted Volume II contains the data reports from the radionuclide analyses Volume III contains the data reports from the water quality parameters

analyses Volumes IV and V contain the data reports from the metals analyses Volume VI contains the data reports from the volatile organic compound analyses

1.0 INTRODUCTION

This report presents the results of the bench-scale treatability study for surface waters at Operable Unit No 2 (OU2) at the Rocky Flats Plant The purpose of this project was to provide technical support in the form of bench-scale treatability tests to the RFP Environmental Restoration Program. These tests were intended to support the Surface Water Interim Measure/Interim Remedial Action (IM/IRA)

A plan for the test program entitled Treatability Study Plan, 903 Pad, Mound, and East Trench Area, Operable Unit Number 2 was issued on October 16, 1990 This Treatability Study Plan (TSP) defined a program of treatability tests for removing volatile organic compounds, suspended solids, and radionuclides from surface waters within OU2 The plan included testing of granular activated carbon for removal of volatile organic compounds and radionuclides, precipitation and filtration for removal of radionuclides and suspended solids, ion exchange for removal of radionuclides, and adsorbents for removal of radionuclides

The treatability study program was conducted in November and December, 1990 Considerable difficulties were encountered during the field sampling program in obtaining sufficient volumes of surface water from the sampling locations specified in the TSP In addition, the levels of radionuclides in the surface water collected were too low to conduct the tests for radionuclide removal The tests for removal of volatile organic

compounds using granular activated carbon and suspended solids removal using coagulation/precipitation and filtration were completed

Treatability tests involving radionuclides were planned to be re-initiated in the spring of 1991, when surface water would be more available It turned out, however, that sufficient supplies of radionuclide-contaminated surface water were still not available Additionally, by that time, design of the full size surface water treatment system was being finalized Since the results from the treatability study tests would not be available in time to support the design effort, emphasis was shifted to the field-scale treatability tests, and the bench-scale tests for radionuclide removal were not completed for this report

2.0
TREATABILITY TEST PROGRAM OBJECTIVES

The treatability program defined in the TSP included the following tests

- GAC for removal of volatile organic compounds
- GAC for removal of radionuclides
- Ion exchange for removal of radionuclides
- Adsorbents for removal of radionuclides
- Chemical coagulation/microfiltration for removal of radionuclides
- Coagulation/precipitation/filtration for removal of suspended solids

As stated previously, no tests for removing radionuclides were performed due to the low levels of radionuclides measured in the surface water collected for testing The following tests were performed

- GAC for removal of volatile organic compounds
- Coagulation/precipitation/filtration for removal of suspended solids

The objective of the GAC treatability test was to evaluate the removal efficiencies of various types of GAC for the treatment of organic contaminants in the surface water at the RFP The organics of interest include vinyl chloride, methylene chloride, 1,1-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethene (total), carbon tetrachloride, trichloroethene, and tetrachloroethane

The primary objective of the coagulation/precipitation/filtration test was to determine the most effective coagulant and its corresponding optimum dosage and operating pH The effectiveness of filtration for further reduction of suspended solids was also evaluated

3.0 FIELD SAMPLING PROGRAM

The following subsections reference the Sampling and Analysis Plan (SAP), which is Appendix B to the TSP, and the Field Sampling Plan (FSP) and the Laboratory Analysis Plan (LAP), which are Appendixes B-1 and B-2, respectively, to the TSP Surface water samples were collected for use in the treatability tests The sampling was performed in accordance with the SAP and Rocky Flats Standard Operating Procedures (SOP) The SAP was written specifically for this program and included all field and laboratory studies An FSP was prepared to guide field water sample collection efforts The FSP set forth guidelines to evaluate site-specific conditions, meteorologic and hydrologic characteristics and contaminant distribution data in order to obtain water samples that could be used for treatability testing The following subsections discuss constituents proposed for analysis, the number and volume of samples that were to be taken, proposed sampling locations, proposed sampling dates, and deviations from the FSP

3.1 LOCATIONS SAMPLED

Figure 3-1 illustrates the proposed locations of the sampling sites, as designated in Figure B-1-1 of the FSP The proposed sites included the following

SW-50	SW-55	SW-61
SW-51	SW-57	SW-63

SW-52	SW-58	SW-64
SW-53	SW-59	SW-77

Details concerning the locations of the proposed sampling sites relative to the 903 Pad, Mound, and East Trenches Areas of Operable Unit No 2 are provided in Subsection 1 1 of the FSP and in Section 3 4 of this report

The objective of the field sampling program was to obtain water samples that were to be used in assessing the performance of various treatment alternatives A primary requirement for water samples used in the treatability study was that the samples contain contaminant concentrations which were within the average to high range of concentrations historically exhibited at the site This requirement and the hydrogeologic factors which limited the number of sites available for sampling during the sampling period were the primary factors which determined sample location selection and sampling procedures However, fire safety restrictions prevented sampling at site SW-53 on November 29, 1990 and December 5, 1990 No vehicle traffic was permitted in the buffer zone area on these dates because of dry conditions, which produced a high fire risk

3.2 SAMPLE COLLECTION METHODS

Sample collection methods were described in Section 3 4 of the FSP The precise volumes of water taken from a given site on a given date depended on the flow conditions at the time of the sampling event Depending upon the number of sites containing water at the time of the sampling, approximately equal volumes were to be collected at each site, if each site produced sufficient water to permit this

In the FSP, the water samples were to be placed in polyethylene carboys of approximately 5 gallons capacity each Due to the handling ease and improved cooling ability to be gained by using 1-gallon polyethylene bottles and 4-liter containers, these containers were substituted for the carboys Also, in order to minimize volatilization of volatile organic compounds (VOCs), one-liter glass containers with lids fitted with septa were used to collect samples to be used in VOC treatability tests No chemical preservatives were used in the treatability samples The samples were cooled as described in Rocky Flats Plant Surface Water Data Collection Program Standard Operating Procedure No 3, Sample Containers, Preservation, Handling, Packaging, and Shipping The surface water samples were not composited in the field

Sampling activities were performed and documented in accordance with the following Rocky Flats Plant Surface Water Data Collection Program Standard Operating Procedures

- SOP No 2 Sample Control and Documentation
- SOP No 4 General Equipment Decontamination
- SOP No 5 Level D Personnel Decontamination
- SOP No 9 Waste Management
- SOP No 13 Chain of Custody Procedures
- SOP No 14 Logbook Protocol

Prior to the scheduled sampling event, existing hydrologic conditions were assessed to determine the presence of water available for sampling at the sampling locations Based on this information, the greatest volumes of water were to be collected from sites producing the highest discharge of water

3.2.1 Sampling Events, Dates, and Quantities

Four weekly sampling events were anticipated The events were scheduled to occur on or about the dates listed in Section 5 0 of the TSP Quantities proposed to be collected are also listed in Section 5 0 of the TSP As described in Section 3 4 of the FSP, approximately 250 gallons of water samples were to be obtained for use in the treatability studies The volumes to be obtained each week for use in the treatability tests varied, depending upon the types of tests being performed during a given week Table B-1-1 of the TSP lists the approximate volumes of surface water required for use in the treatability tests The volumes of water listed in Table B-1-1 would include sufficient sample to provide (1) sample for the characterization of source material, as discussed in the TSP, Appendix B, Section 2 0, (2) samples for treatability tests, as listed in Table B-1-1, and (3) sufficient residual for testing of end products

3.3 DEVIATIONS FROM ORIGINAL FIELD SAMPLING PLAN

The IM/IRA Plan (IM/IRAP document), September, 1990 describes the suspected contaminant sources in OU2 Section 2 5 of the TSP details the contaminant distribution. Surface water contaminant distribution is described in Section 2.5 2 of the TSP Section 2 5 2 of the TSP presents five tables from the IM/IRAP document to list chemical-specific ARARs and flow-weighted maximum concentrations of the contaminants of concern. Table 2-5 of the TSP presents flow-weighted maximum concentrations at various groups of stations The data presented in the table include the average and maximum concentrations at the group of stations, the estimated flow at the group of stations based on wet season flow measurement, the flow-weighted average concentration, and the flow-weighted maximum concentrations Flow-weighted averaging is intended to define the probable influent average and maximum concentrations for these constituents for the IM/IRA treatment system. Therefore, when selecting sites for sampling during the field activities, the data in Table 2-5 were used to select sites

containing the average to maximum concentrations found in the surface water locations The data contained in the TSP were used to determine which of the surface water sites containing water at the time of the scheduled sampling event possessed the maximum historic concentrations of VOCs and/or radionuclides The sampling effort concentrated on collecting as much water as was possible from such sites

The IM/IRAP document contains water quality data for samples obtained from several surface water locations downslope to the southeast of the 903 Pad The surface water stations described in the IM/IRAP document which, if flowing, would be sampled under the treatability test program were SW-50, SW-51, SW-52, SW-55, SW-57, SW-58, and SW-77 In addition to these stations, samples for treatability testing purposes would also be taken from the following stations SW-53, SW-63, and SW-64, if flowing

Station SW-50 is closest to the 903 Pad, and SW-57 and SW-52 are south of SW-50 SW-51 and SW-58 are located in a ditch along the road east of SW-50, however, overland flow from SW-50, SW-52, and SW-57 may also enter the ditch Water in the ditch passes under the road south of these locations through a culvert The discharge of the culvert is SW-55 SW-77 is another surface water location on the east side of the road, immediately northeast of SW-55 The IM/IRAP document notes that SW-51, SW-58, and SW-55 are physically connected and they likely receive flow from SW-50, SW-52, and SW-57 Farther downgradient stations include surface water locations at SW-53, SW-63, and SW-64

Surface water stations associated with Upper South Walnut Creek which were to be sampled during this program include SW-59 and SW-61 The flow in South Walnut Creek upstream of Pond B-4 is primarily the combined flow from the discharge of culverts and a spring (SW-59) located at the base of the hill to the south and downstream of the culverts SW-61 is located at the confluence, providing a point for sampling combined flow

As noted in Section 2 5 2 1 of the TSP, data for surface water locations in the vicinity of the 903 Pad Lip Site indicate that trichloroethene (TCE) is occasionally present at SW-53, and low concentrations of TCE occur at SW-63 (<0 020 μg/L) and at SW-64 Data for stations SW-59 and SW-61 indicate the presence of TCE in concentrations in excess of 200 μg/L

As also noted in Section 2 5 2 1 of the TSP, surface water locations in the vicinity of the 903 Pad Lip Site, particularly SW-50 and SW-53, contained detectable plutonium and/or americium during one event in 1989, with two such events for SW-53 The samples contained substantial suspended solids and were not filtered at the time of collection Surface soils in the vicinity of the surface water locations are contaminated with radionuclides Further, total radiochemistry indicated notable higher plutonium and americium concentrations in unfiltered samples than in filtered samples, which the IM/IRAP document interprets to mean that most of the radionuclides are present in a particulate form

The TSP reported that analytical results for a sampling program which involved collection and incremental filtration of samples obtained at the 903 Pad Lip Area appeared to support the hypothesis that plutonium and americium were primarily associated with particles in excess of 0 45 μm in size These data indicated that the highest concentrations of total radionuclides were found in water samples obtained from SW-53, SW-55, SW-58, and SW-77 None of these sites were expected to contain water for sampling purposes during the months of October or November, however, site SW-53 contained small amounts of water in November

A primary requirement for surface water samples to be used in the treatability study was that the samples contain contaminant concentrations within the average to high range of concentrations historically exhibited at the site The hydrologic factors associated with the site affected sampling activities by limiting the number of sites containing water at

the time of scheduled sampling events Sites were presurveyed for the presence of water available at the site for sampling prior to the sampling dates

Table 3-1 presents the status of the surface water stations as surveyed prior to the sampling events With the exceptions of sites SW-53, SW-55, SW-59, SW-61 and SW-64, the sites were dry for the duration of the sampling and treatability testing efforts Of these sites, SW-53 and SW-59 were selected as best representing the water quality and source areas needed for treatability testing, therefore, sites SW-53 and SW-59 were used to obtain samples SW-53 (903 Lip Area), located in a zone of americium contamination was a small hole containing extremely turbid water, but it was possible to obtain small amounts for the treatability tests on removal of TSS Due to the water quality considerations and flow availability restrictions discussed above, only sites SW-53 and SW-59 were used to obtain samples for use in treatability testing

Table 3-2 lists the dates on which samples were collected, the sample collection site used for obtaining the samples, the total volume of the samples, sample containers used, and the dates on which the samples arrived at the treatability laboratory As previously noted, glass bottles, one-gallon polyethylene bottles, and 4-liter polyethylene cubitainers were substituted for the large, polyethylene carboys originally proposed as sample containers in the FSP To minimize the loss of volatiles during the filling of sample containers, 1-liter glass bottles were substituted for the large, polyethylene carboys discussed in Subsection 3 2 The bottle caps were fitted with a septum to permit the bottle to be filled with no headspace For ease of handling, samples collected for use in total suspended solids treatability tests were collected into 4-liter cubitainers, rather than the polyethylene carboys Some samples were also collected in 1-gallon polyethylene bottles

3.4 CHEMICAL CHARACTERIZATION OF SAMPLES

The constituents analyzed are discussed in Appendix A-2 of the TSP, the Laboratory Sampling Plan, Section 2 1, Laboratories and Analytes

3.4.1 Radiation Screening

Samples collected in the field required radiation screening before they could be shipped offsite from RFP to the laboratory This process required from one to two days The samples were hand-delivered to the 881 Lab at RFP by the field sampling team, and were kept cool while at the 881 Lab and during shipment to the treatability test laboratory Additional gross alpha/beta screening of some field water samples was performed at the treatability test laboratory using alpha-beta counting methods

3.4.2 Analysis for VOCs, Metals, Radionuclides

The composited water samples from the field were characterized before their use in the treatability tests The samples were analyzed for the volatiles suite, metals suite, radionuclide suite, and water quality parameters listed in Tables B-2-2 and B-2-3 of Appendix B-2 to the TSP

Analytical results for composited water characterization (CWC) samples are contained in Exhibit A. The laboratory data reports for these analyses are contained in Volumes II through VI of this report

3.4.3 Data Validation

The data were evaluated at the levels specified in Section 3 4 of Appendix C of the Treatability Study Plan in accordance with the guidelines stated in EG&G Data

Validation Functional Guidelines (EG&G 1990b) This included a review of the analytical laboratory data package for completeness and acceptability of the information listed in Table C-3 of Appendix C of the TSP The chains of custody, holding times, results of method blanks, laboratory control samples, and other laboratory quality control (QC) samples, results of calibration, and results of QC samples submitted from the bench scale treatability studies were reviewed

The overall data quality was considered excellent, with very few sample results requiring qualification The thallium results in several samples and the iron result in one sample were flagged as estimated, meaning that the letter "J" appears to the right of the analytical result to indicate that the value is estimated due to poor matrix spike recovery All data results were valid so that completeness was 100 percent

TABLE 3-1

CHRONOLOGY OF FIELD SAMPLING

Survey Date	Surface Water Station	Conditions/ Observations
9/19/90	SW-61	Sampled for site-wide surface water program Approximately 18 8 liters collected on 9/19/90
9/20/90	SW-77	Dry
9/20/90	SW-50	Dry
	SW-51	Dry
	SW-52	Dry
	SW-53	Dry
	SW-55	Dry
	SW-57	Dry
	SW-58	Dry
9/25/90	SW-59	Sampled for surface water monitoring site-wide program Approximately 18 8 liters collected on 9/25/90
11/6/90	SW-59	Collected 47 liters for Treatability Testing
11/12/90	SW-59	Collected 57 liters for treatability testing
	SW-53	Collected 19 liters for treatability testing
11/19/92	SW-50	Dry
	SW-51	Dry
	SW-52	Dry
	SW-53	Contains approximately 12 liters of very silty water
	SW-55	No apparent flow, contains approximately 1 liter of standing water
	SW-57	Dry
	SW-58	Dry
	SW-59	Flow less than 1 liter/minute
	SW-61	Flow approximately 10 liters/minute
	SW-63	Dry

TABLE 3-1
(Concluded)

Survey Date	Surface Water Station	Conditions/ Observations
11/19/92	SW-64	Site is a depression resembling a large tire rut, contains 2 to 3 gallons of water, which may be either surface runoff or snowmelt
	SW-77	Dry
11/26/90	SW-59	Collected 111 liters for treatability testing
12/5/90	SW-59	Collected 80 liters for treatability testing

TABLE 3-2

SURFACE WATER SAMPLING DATES, COLLECTION SITES, VOLUMES, AND CONTAINERS

Date Samples Were Collected	Collection Site	Sample Volume	Container Type and Number of Containers	Date Samples Arrived at the Lab
11/6/90	SW-59	*47 liters	1-liter glass bottles/47	11/8/90
11/12/90	SW-59	**57 liters	1-gallon polyethylene bottles/15	11/14/90
11/12/90	SW-53	19 liters	1-gallon polyethylene bottles/5	11/14/90
11/26/90	SW-59	*51 liters	1-liter glass bottles/51	11/27/90
11/26/90	SW-59	**60 liters	4-liter cubitainers/15	11/27/90
12/5/90	SW-59	80 liters	4-liter cubitainers/20	12/6/90

* Used for VOA treatability tests
** Used for suspended solids treatability tests

4.0 BENCH TEST PROGRAM

4.1 COAGULATION/PRECIPITATION/FILTRATION TESTS

4.1.1 Objective

As stated in the TSP these tests were to evaluate the method to remove suspended solids from OU2 surface water Removal of suspended solids was considered essential to prevent fouling or plugging of subsequent treatment operations in the OU2 IRA. The objective of these tests was to evaluate the effectiveness of various coagulants for removing suspended solids from OU2 surface waters Optimum dosages and operating pH levels were also evaluated The benefits of using a polymer as a coagulant were also investigated Finally, the effectiveness of filtration for further reduction of suspended solids was studied The evaluation of suspended solids removal was the only objective of these tests A separate test program to evaluate coagulation/filtration for radionuclide removal was included in the TSP These tests were not conducted because of low radionuclide levels in the surface water samples, as discussed previously

The tests were conducted in three rounds The first round of tests was to screen the coagulants to establish those which were most effective and to determine the optimum dosages and pH values The second round of tests provided further evaluation of these variables and also included testing of polymer coagulants The third round of testing added filtration tests

4.1.2 Test Method and Equipment

Coagulation/precipitation was evaluated using jar tests A multiple jar testing apparatus with paddle stirrers was used One-liter samples were used during the first two rounds of tests, and five-liter samples were used for the third round

The first step in the jar test procedure was adjustment of the pH as necessary with the addition of hydrochloric acid or sodium hydroxide Sufficient reagent was added to achieve the target pH, the amount added was not recorded The coagulants were added to each jar at the desired dosage and the solution was rapidly mixed for one minute The solution was than mixed at slow speed for 20 minutes Then the solids were allowed to settle for 15 minutes The nature and settling rate of the suspended solids were recorded After the solid settling period, a sample of the supernatant water above the settled solids was collected for analyses The supernatant sample was only analyzed for total suspended solids (TSS) content for rounds one and two The supernatant sample was also analyzed for metals and water quality parameters for round three The final temperature and pH were recorded for each jar test A sample of the inlet water prior to pH adjustment or coagulant addition was analyzed for the same parameters as the jar test samples to establish base conditions prior to treatment

The third round of testing included filtration of the jar test liquid following settling of suspended solids The supernatant was decanted from the jar and filtered through a sand filter Filter testing was done using a 1-inch diameter glass column filled with 2 feet of filter sand A feed tank and peristaltic pump were used to pump the water through the columns The rate of fluid flow through the column and the time required to filter the volume of supernatant was recorded A sample of the filtrate was analyzed for TSS, water quality parameters, and metals

Details of the test apparatus and procedures are given in the Treatability Study Work Plan, which is Appendix A of the TSP

4.1.3 Test Runs

Three rounds of testing were conducted The results from previous test rounds were used to select test parameters for subsequent rounds

4.1.3.1 Round 1 Testing

The first round of testing included testing of all five coagulants selected in the TSP These coagulants were tested at variable dosages and pH levels The objective of this round was to screen the coagulants to select the most effective for further testing and to establish the optimum dosages and pH levels

The following coagulants were tested

- Aluminum sulfate
- Ferrous sulfate
- Ferric sulfate
- Ferric chloride

Each of these coagulants was tested at the following dosages and pH levels

- 15 mg/L and 25 mg/L
- pH 6, 8, 10, and 11

The experiments were conducted using surface water collected from location SW-59 on November 12, 1990 The initial characterization of this water has been discussed in

Section 3 and the results of the analyses are presented in Exhibit A. A sample of this water was taken for gross alpha and beta radioactivity screening on November 14 (sample number 02CWC1001) and the results are presented in Table A-5 A sample of this water was taken on November 20, 1990 (sample number 02CWC1003) and analyzed for water quality parameters, metals, volatile organic compounds, and radionuclides The results are presented in Tables A-1 through A-4

Table B-1 in Exhibit B presents the results for the Round 1 tests This table includes data on the test conditions, TSS analyses, and visual observations of floc formation and settling rates The Round 1 tests were conducted between November 21 and November 27, 1990 Inlet samples of the water before treatment were collected and analyzed for TSS on November 21 and November 27 and the results reported were 11 mg/L and <5 mg/L (detection limit), respectively Analysis for TSS was the only chemical analysis conducted for the Round 1 jar tests consistent with the TSP The laboratory data reports for the TSS analyses are included in Volume III of this report

The conclusions drawn from the Round 1 tests were primarily based on the visual observations of the quantity and characteristics of the suspended solid floc which formed and the rate of solids settling The low levels of TSS reported in the untreated water and the low levels measured in most of the jar test samples made it difficult to base judgement of coagulant performance on these analyses The objective of the tests was to determine optimum conditions for removal of suspended solids from the untreated water The levels of suspended solids in the untreated water were so low that treatment in many cases produced little or no reduction and in some cases increased the suspended solids content Therefore, evaluation of the optimum coagulants, coagulant doses, and pH levels was based primarily on observations of the amount and type of floc which formed and the settling rate

Review of the data in Table B-1 indicated that for all coagulants tested at high pH values, considerable precipitation occurred during pH adjustment This was probably due to the precipitation of dissolved metal cations present in the untreated water, principally calcium and magnesium The objective of the tests was to use coagulants to remove suspended solids, not to precipitate dissolved metals Therefore, the maximum pH used for the Round 2 and 3 tests was 10 Aluminum sulfate did not produce a visible floc except at the high pH values As stated, this floc formation was likely due to precipitation of dissolved metals and so aluminum sulfate was deleted from testing in Rounds 2 and 3 There appeared to be no benefit to using the higher dosage of 25 mg/L for the iron coagulants versus the 15 mg/L dosage The dosage of iron coagulants was limited to 15 mg/L for Rounds 2 and 3

4.1.3.2 Round 2 Testing

The second round of testing included testing of the iron coagulants retained after the first round of tests The use of two polymer coagulant aids was included in the Round 2 tests as well The objectives of the second round of tests was to further evaluate the coagulants and pH levels prior to the final round of testing which was to include filtration tests as well

The second round of testing included the following conditions

- Coagulants - ferrous sulfate
  ferric sulfate
  ferric chloride

- Coagulant aids (polymer)
  Nalco 8102 (cationic) at 1 0 mg/L
  Nalco 8182 (slightly anionic) at 0 5 mg/L

- pH levels

  unadjusted (natural water pH)
  8
  10

The coagulant dosages were maintained at 15 mg/L for the Round 2 tests

The experiments were conducted using surface water collected from location SW-59 on November 12 and 26, 1990 The initial characterization of these waters has been discussed in Section 3, and the results are presented in Exhibit A. A sample of the water collected on November 12 was taken on November 14 (sample number 02CWC1001) for gross alpha and beta radioactivity screening, and results are presented in Table A-5 A sample was taken on November 20 (sample number 02CWC1003) and analyzed for water quality parameters, metals, volatile organic compounds, and radionuclides The results are presented in Tables A-1 through A-4 A sample of the water collected on November 26 was taken on November 28 (03CWC1005) and submitted for analysis of water quality parameters, metals, and radionuclides The results are presented in Tables A-1, A-2, and A-4, respectively

Table C-1 in Exhibit C presents the results for the Round 2 tests The table includes data on the test conditions, TSS analyses, and visual observations of floc formation and settling rates The Round 2 tests were conducted on November 29 and 30, 1990 Inlet samples of the water before treatment were collected and analyzed for TSS on November 29 and 30 and the results reported were 7 mg/L and <5 mg/L, respectively Analysis for TSS was the only chemical analysis conducted for the Round 2 jar tests consistent with the TSP The laboratory data reports for the TSS analyses are included in Volume III of this report

The conclusions drawn from the Round 2 tests were primarily based on visual observations of the quantity and characteristics of the suspended solid floc which formed and the rate of solids settling The low levels of TSS reported in the untreated water and the low levels measured in most of the jar tests made it difficult to base judgement of coagulant performance on these analyses

Review of the data in Table C-1 indicated that the ferrous sulfate coagulant produced no or very small floc that did not settle Ferrous sulfate was deleted from testing in Round 3 There did not appear to be any advantage to using a pH level of 10 for any of the coagulants The pH levels for the Round 3 tests were limited to natural unadjusted pH and a pH of 8

The Nalco 8182 polymer coagulant aid appeared to improve minimally the ferric chloride performance but did not appear to improve the performance of the ferric sulfate Testing of higher dosages of Nalco 8102 was included in the Round 3 tests

4.1.3.3 Round 3 Testing

The third round of testing included testing of the coagulants retained after the first two rounds of tests The use of filtration through a sand column to increase the removal of suspended solids was also included in the Round 3 tests The water samples were chemically analyzed for water quality parameters and metals for the Round 3 tests

The third round of testing included the following conditions

- Coagulants - none
  ferric sulfate at 15 mg/L
  ferric chloride at 15 mg/L

- Coagulant aids (polymer)

  Nalco 8102 (cationic) at 1 0 and 2 0 mg/L
  Nalco 8182 (slightly anionic) at 0 5 mg/L

- pH levels

  unadjusted (natural water pH)
  8

The experiments were conducted using surface water collected from location SW-59 on December 5, 1990 The initial characterization of this water has been discussed in Section 3, and the results are presented in Exhibit A. A sample of this water was taken on December 7, 1990 (04CWC1006) and submitted for analysis of water quality parameters, volatile organic compounds, metals, and radionuclides The results are presented in Tables A-1 through A-4

Table C-1 in Exhibit C presents the results for the Round 3 tests The table includes data on the test conditions, TSS analyses, visual observations of floc formation and settling rates, and filtration rates The Round 3 tests were conducted from December 7 through 11, 1990 Inlet samples of the water before treatment were collected and analyzed for TSS on December 7 and 10, and the results reported were <3 3 mg/L and 3 7 mg/L, respectively The samples collected during the Round 3 tests were also analyzed for water quality parameters and metals, and these results are presented in Tables D-2 and D-3, respectively The laboratory data reports for the analyses are included in Volumes III, IV, and V of this report

The suspended solids levels in the surface water used for the Round 3 tests were very low There was no significant difference in the TSS values after filtration between the control sample (no coagulant addition or pH adjustment) and the other test samples

Review of the data in Table D-2 indicates that the water quality parameters were similar for all samples

Review of the data on total metals content in Table D-3 indicates that, with the exception of iron, the metals which were reported at elevated concentrations (Ba, Ca, Mg, K, Na, Zn) did not exhibit significant differences with pH levels, coagulant addition, or before or after filtration The levels of iron were in general higher for samples which were dosed with ferric chloride or ferric sulfate and the levels were reduced by filtration These results are as expected In many cases, the concentrations reported for samples after coagulation or coagulation and filtration were higher than concentrations reported for the untreated water for metals detected at low levels These data may be due to impurities present in the chemicals added or may be due to laboratory anomalies The heavy metals As, Cd, Cr, Ni, Tl, and V were reported at levels significantly greater than detection limits for only a few samples, and the values for the inlet water samples prior to coagulant addition or pH adjustment were in almost all cases below detection limits No significant conclusions can be drawn with regard to removal of these metals by precipitation and filtration Review of the data in Table D-3 indicates that no significant conclusions can be drawn regarding reductions in the concentration of Al, Cu, Pb, or Mn

4.2 GRANULAR ACTIVATED CARBON (GAC) TESTS

4.2.1 Objective

The objective of these tests was to evaluate the use of GAC for the removal of volatile organic compounds from surface water at the Rocky Flats Plant The evaluation of removal of radionuclides was also an objective in the TSP However, due to the low levels of radionuclides present in the surface water collected during the test program, testing for radionuclide removal was not conducted The tests were conducted in three

rounds The objective of the first round of testing was to establish VOC removal efficiencies for a number of different types of GAC and to select the two most promising types of GAC for further testing The second round of testing was intended to establish compound-specific removal efficiencies for the two types of GAC selected from the Round 1 tests The third round of testing was intended to determine breakthrough behavior for the two types of GAC The low levels of VOCs present in the surface water samples and the difficulty encountered in obtaining adequate volumes of surface water forced some modifications to these objectives, as will be described

4.2.2 Test Method and Equipment

The use of GAC for VOC removal was evaluated using fixed columns of GAC Five columns were operated in parallel for the first two rounds of testing, and one column was used for the third round of testing The glass columns were 1 inch in diameter and were filled with approximately 1 foot of GAC for the first two rounds of testing and approximately 5 inches of GAC for the third round of testing The surface water was fed to the columns using peristaltic pumps All flow to the columns was downflow The suspended solids content of the feed water was so low that no filtration was required prior to GAC columns

The evaluation of performance for the first two rounds of testing was based on the comparison of organic compound analysis of a grab sample of the inlet water and grab samples of water collected from the outlet of each column at the conclusion of the test run Multiple grab samples were collected from the outlet of the test column for the third run The performance data for Rounds 1 and 3 were based on percent reduction in peak area using an on-site gas chromatograph (GC) for analysis of organic compounds The performance data for the Round 2 tests were based on compound-specific analysis of organic compounds at a commercial laboratory The Round 2 tests also included analysis for water quality parameters

Details of the test apparatus and procedure are given in the Treatability Study Work Plan, which is Appendix A of the TSP

4.2.3 Test Runs

Three rounds of testing were conducted The Round 1 tests evaluated the removal efficiency of total VOCs for five different types of GAC The intent was to select the two most promising types of GAC for further testing However, the results obtained did not provide any basis for selection and so all five types of GAC were included in the Round 2 tests The Round 2 tests evaluated the removal efficiencies for individual VOCs The results of the Round 2 tests did not provide any basis for comparison of the different types of GAC A single type of GAC was selected for the third round of testing The Round 3 tests evaluated the breakthrough behavior based on the removal of total VOCs

4.2.3.1 Round 1 Tests

The first round of testing included evaluation of the removal efficiencies of all five GAC specified in the TSP The objective of this round was to screen the different types of GAC to select the two most promising for further evaluation The five types of GAC tested were

- Calgon Filtersorb 300 (12x40 mesh)
- Calgon Filtersorb 400 (12x40 mesh)
- Norit 4000 (12x40 mesh)
- Yakima CYP (12x40 mesh)

- Yakima C-C (12x40 mesh)

The experiments were conducted using surface water collected from location SW-59 on November 6, 1990 The initial characterization of this water has been discussed in Section 3 0, and the results of the analyses are presented in Exhibit A. A sample of this water was taken on November 13, 1990 (sample number 01CWC1001) and submitted for analysis for water quality parameters, metals, volatile organic compounds, and radionuclides The results are presented in Tables A-1 through A-4

The Round 1 tests were conducted using a GAC bed depth of approximately 1 foot, a feed rate of 10 ml/min, and a run duration of 4 hours, as specified in the TSP An inlet water sample was collected at the start of the testing and an outlet sample was collected from each of the five columns at the end of the test run. The evaluation was based on reduction in total peak area using an on-site GC for analysis of the VOC content of the samples The peak areas were expressed as total organic compounds (TOC) calibrated as 1,1-dichloroethene (1,1-DCE)

The results for the Round 1 tests are presented in Exhibit E The run parameters for the Round 1 tests are summarized in Table E-1 The Round 1 tests were conducted on November 14, 1990

The results for GC analysis of the samples are presented in Table E-2 All of the GAC types tested removed 100 percent of the TOC in Round 1 This can be attributed to the low levels of VOCs in the water and to the limited volume of water (less than 20 bed volumes) treated There was no basis for selection of two GAC types for further testing, so all five GAC types were retained for the Round 2 tests

4.2.3.2 Round 2 Tests

The objective of the second round of testing was to evaluate the removal efficiencies of the five types of GAC for individual volatile organic compounds Analysis of water quality parameters was also included in this round of testing

The experiments were conducted using surface water collected from location SW-59 on November 6, 1990 The initial characterization of this water has been discussed in Section 3, and the results of the analyses are presented in Exhibit A. A sample of this water was taken on November 13, 1990 (sample number 01CWC1001) and submitted for analysis for water quality parameters, metals, volatile organic compounds, and radionuclides The results are presented in Tables A-1 through A-4

The Round 2 tests were conducted using a GAC bed depth of approximately 1 foot, a feed rate of 30 ml/min, and a run duration of 2 hours, as specified in the TSP An inlet water sample was collected at the start of the testing, and an outlet sample was collected from each of the five columns at the end of the test run These samples were submitted to commercial laboratories for analysis of individual VOCs and water quality parameters The laboratory data reports for the water quality analyses and VOC analyses are included in Volumes III and VI, respectively, of this report

The results for the Round 2 tests are presented in Exhibit F The Round 2 tests were conducted on November 26, 1990 Table F-1 summarizes the test run parameters

The results reported for the analysis for volatile organic compounds are presented in Table F-2 Review of the data in Table F-2 indicates that all of the GAC types tested removed 100 percent of every volatile organic compound detected in the inlet water This can be attributed to the low levels of VOCs in the water and to the limited volume of water (less than 24 bed volumes) treated The procedures for the Round 3 testing

were modified from the TSP in an attempt to achieve breakthrough A single type of GAC was selected for an extended run.

The results reported for analysis of water quality parameters for the Round 2 samples are presented in Table F-3 The suspended solids content of the inlet water was below the detection limit, and no changes occurred during flow through the GAC columns The pH increased after passing through all of the GAC columns This change in pH is common when water is contacted with virgin GAC

4.2.3.3 Round 3 Tests

The objective of the third round of testing was to evaluate the breakthrough behavior of a GAC column in treating VOC-contaminated surface water An extended run was conducted using a single column of GAC

The experiments were conducted using surface water collected from location SW-59 on November 26, 1990 The initial characterization of this water has been discussed in Section 3, and the results of the analyses are presented in Exhibit A. A sample of this water was taken on November 27, 1990 (sample number 03CWC1004) and submitted for analysis for volatile organic compounds The results are presented in Table A-3

The Round 3 test was conducted using a GAC bed depth of approximately 5 inches and a feed rate of 30 ml/min The bed depth was reduced from the 1 foot used in the Round 1 and 2 tests in order to increase the opportunity for breakthrough A sample of the inlet water was collected prior to starting the test The flow of water through GAC was initiated and allowed to continue overnight for a period of approximately 15 hours before collection of the first outlet sample Additional outlet samples were collected at intervals of approximately 2 hours until all of the available inlet water had been processed The samples were analyzed using the on-site GC, and the results were

evaluated based on reduction in total peak areas The peak areas were expressed as TOC calibrated as 1,1-DCE

The results for the Round 3 tests are presented in Table G-1 of Exhibit G The Round 3 test was conducted on November 27 and 28, 1990 The results indicate that the first effluent sample showed detectable amounts of TOC The TOC levels in subsequent samples showed a slow but steady increase until the test was terminated when the available feed water was used up This data indicate that column breakthrough may have begun after 379 or fewer bed volumes had been processed However, the use of only a 5-inch bed depth may have produced premature indication of breakthrough due to the length of the mass transfer zone exceeding the available bed depth

5.0
SUMMARY AND CONCLUSIONS

Bench-scale treatability studies for OU2 surface waters have been completed These tests were done to provide technical support to the Rocky Flats Plant Environmental Restoration Program

Bench scale tests were performed on the following technologies

- Coagulation/precipitation/filtration for removal of suspended solids
- GAC for removal of VOCs

The original test plan included bench scale tests of several technologies for removing radionuclides However, due to the unavailability of radionuclide contaminated surface waters, these tests were not performed

The coagulation/precipitation/filtration tests evaluated the following coagulants and coagulant aids

- Aluminum sulfate
- Ferrous sulfate
- Ferric sulfate
- Ferric chloride
- Nalco 8102 (cationic polymer)

- Nalco 8182 (slightly anionic polymer)

The tests were conducted in three rounds The first two rounds included solid settling alone while the third round of tests included filtration through sand columns following solid settling The evaluation of suspended solids removal was hampered by the low levels of total suspended solids (at or slightly above the detection limit) present in the surface water used for the tests The evaluation was primarily based on visual observations of the nature of the solids floc which formed and the settling rates

It was found that both the aluminum sulfate and ferrous sulfate were not as effective as both ferric sulfate and chloride Adjustment of pH by caustic did not improve the results The Nalco 8182 marginally improved ferric chloride performance but did not appear to help the ferric sulfate

The water used for the Round 3 tests was low in suspended solids It was found that filtration without additives was equally effective compared to filtration for test runs involving addition of coagulants Therefore, the use of direct filtration without additives during periods of low surface water suspended solids concentrations is probably feasible

Five different types of GAC were evaluated for removal of VOCs Three rounds of tests using columns of GAC were conducted The evaluation of GAC performance was hampered by the low levels of VOCs in the surface water used for the tests and the limited volumes of water that were treated The five GAC types tested exhibited identical performance during the first two rounds of tests, removing 100 percent of the VOCs present in the inlet water A single type of GAC, Calgon F 400, was tested in the third round in an attempt to demonstrate breakthrough of VOCs during an extended run The resulting data may indicate that breakthrough started after treatment of less

than 380 bed volumes of surface water However, the conditions used for the test do not allow definite conclusions to be drawn regarding breakthrough behavior

6.0 REFERENCES

EG&G 1990a Treatability Study Plan 903 Pad, Mound, and East Trenches Study Areas, Operable Unit No 2 EG&G Rocky Flats Plant, Golden, CO U S Department of Energy October 1990

EG&G 1990b Data Validation Functional Guidelines Environmental Restoration Department, Environmental Monitoring and Assessment Division EG&G Rocky Flats Plant, Golden, CO Draft, March 1990

TABLE A-1 INITIAL SURFACE WATER CHARACTERIZATION FOR WATER QUALITY PARAMETERS

Surface Water Collection Location		SW059	SW059	SW059	SW059
Surface Water Collection Date		11-06-90	11-12-90	11-26-90	12-05-90
Sample Number		01CWC1001	O2CWC1003	03CWC1005	04CWC1006
Analytes	Units				
Chloride	mg/L	79 0	94 7	56 2	59 2
Carbonate	mg CaCO3/L	359	399	392	392
Fluoride	mg/L	1 10	1 00	1 16	1 10
Nitrate plus Nitrite	mg N/L	2 52	2 34	4 15	3 31
pH	pH units	7 20	7 21	7 60	7 31
Sulfate	mg/L	51 1	49 3	51 4	50 2
Specific Conductance	umhos/cm	813	780	791	960
Total Dissolved Solids	mg/L	615	645	545	585
Total Suspended Solids	mg/L	10 0	5 0	<3 3	<3 3

TABLE A-2 INITIAL SURFACE WATER CHARACTERIZATION FOR METALS

Surface Water Collection Location		SW059	SW059	SW059	SW059
Surface Water Collection Date		11-06-90	11-12-90	11-12-90	12-05-90
Sample Number		01CWC1001	O2CWC1003	03CWC1005	04CWC1006
Analytes	Units				
Aluminum	ug/L	91 9	41 6	38 3	23 8
Antimony	ug/L	<24	<24	<24	<17
Arsenic	ug/L	2 5	2 3	<2	5 3
Barium	ug/L	190	245	209	245
Beryllium	ug/L	<1	<1	<1	<1
Cadmium	ug/L	<3	<3	<3	<1
Calcium	ug/L	109000	121000	11600	140000
Chromium	ug/L	<6	<6	<6	<4
Cobalt	ug/L	<4	<4	<4	<2
Copper	ug/L	<3	<3	15 1	4 3
Iron	ug/L	82 2	98 8	<20	40 0
Lead	ug/L	<2	<2	3 0	2 6
Magnesium	ug/L	30700	33200	31600	36200
Manganese	ug/L	32 8	18 3	15 3	6 4
Mercury	ug/L	<0 2	<0 2	<0 2	<0 2
Nickel	ug/L	12 4	<6	<6	<4
Potassium	ug/L	792	2390	2050	1980
Selenium	ug/L	2 5	<2	<3	<3
Silver	ug/L	<5	<5	<5	<2
Sodium	ug/L	45300	58000	37300	46600
Thallium	ug/L	<10	<10	<10	<3
Vanadium	ug/L	<3	3 1	<3	<3
Zinc	ug/L	304	368	318	328

TABLE A-3 INITIAL SURFACE WATER CHARACTERIZATION FOR VOLATILE ORGANIC COMPOUNDS

Surface Water Collection Location		SW059	SW059	SW059	SW059
Surface Water Collection Date		11-06-90	11-12-90	11-26-90	12-05-90
Sample Number		01CWC1001	O2CWC1003	03CWC1004	04CWC1006
Analytes	Units				
Chloromethane	ug/L	<10	<10	<10	<10
Bromomethane	ug/L	<10	<10	<10	<10
Vinyl Chloride	ug/L	4 3 •	<10	12	<10
Chloroethane	ug/L	<10	<10	<10	<10
Methylene Chloride	ug/L	1 8 •	<5	<5	<5
Acetone	ug/L	<100	<100	<100	<100
Carbon Disulfide	ug/L	<5	<5	<5	<5
1,1-Dichloroethene	ug/L	7 5	2 7 •	5 5	<5
1,1-Dichloroethane	ug/L	4 4 •	3 7 •	4 5 •	4 1 •
1,2-Dichloroethenes, total	ug/L	120	90	150	96
Chloroform	ug/L	41	31	33	25
1,2-Dichloroethane	ug/L	<5	<5	<5	<5
2-Butanone	ug/L	<100	<100	<100	<100
1,1 1-Trichloroethane	ug/L	22	7 8	13	8 3
Carbon Tetrachloride	ug/L	230	59	180	92
Vinyl Acetate	ug/L	<50	<50	<50	<50
Bromodichloromethane	ug/L	<5	<5	<5	<5
1,2-Dichloropropane	ug/L	<5	<5	<5	<5
trans-1,3-Dichloropropene	ug/L	<5	<5	<5	<5
Trichloroethene	ug/L	180	32	120	69
Dibromochloromethane	ug/L	<5	<5	<5	<5
1,1,2-Trichloroethane	ug/L	<5	<5	<5	<5
Benzene	ug/L	<5	<5	<5	<5
cis-1,3-Dichloropropene	ug/L	<5	<5	<5	<5
2-Choroethyl Vinyl Ether	ug/L	<10	<10	<10	<10
Bromoform	ug/L	<5	<5	<5	<5
4-Methyl-2-pentanone	ug/L	<50	<50	<50	<50
2-Hexanone	ug/L	<50	<50	<50	<50
Tetrachloroethene	ug/L	140	5 8	100	27
1,1,2,2-Tetrachloroethane	ug/L	<5	<5	<5	<5
Toluene	ug/L	<5	<5	<5	<5
Clorobenzene	ug/L	<5	<5	<5	<5
Ethylbenzene	ug/L	<5	<5	<5	<5
Styrene	ug/L	<5	<5	<5	<5
Xylenes, total	ug/L	<5	<5	<5	<5

• Detection below reporting limit, quantification may not be reliable

TABLE A-4 INITIAL SURFACE WATER CHARACTERIZATION FOR RADIONUCLIDES

Surface Water Collection Location		SW059		SW059		SW059		SW059	
Surface Water Collection Date		11-06-90		11-12-90		11-26-90		12-05-90	
Sample Number		01CWC1001		O2CWC1003		03CWC1005		04CWC1006	
Analytes	Units	Value	2 x sig (1)	Value	2 x sig (1)	Value	2 x sig (1)	Value	2 x sig (1)
Gross Alpha	pCi/L	6 679	3 593	5 801	3 934	2 653 (2)	3 216	1 881 (2)	3 369
Gross Beta	pCi/L	3 542	1 198	5 382	2 33	5 832	2 409	4 095	2 332
U-233,234	pCi/L	3 826	0 984	3 067	1 053	4 015	0 987	4 649	1 261
U-235	pCi/L	0 171 (2)	0 225	0 083 (2)	0 162	0 113 (2)	0 112	0 361	0 228
U-238	pCi/L	2 645	0 742	3 339	1 073	3 222	0 852	4 649	1 261
Pu-239,240	pCi/L	0 011	0 009	0 012	0 008	(3)		0 024	0 010
Am-241	pCi/L	-0 001 (2)	0 009	0 004 (2)	0 005	0 031	0 015	0 012	0 004

(1) Two times the standard deviation for analysis
(2) Reported value is less than the MDA for the analysis
(3) Results did not pass the yield and MDA requirements

TABLE A-5 INITIAL SURFACE WATER CHARACTERIZATION FOR GROSS ALPHA AND BETA RADIOACTIVITY

Surface Water Collection Location		SW059		SW053	
Surface Water Collection Date		11-12-90		11-12-90	
Sample Number		02CWC1001		02CWC1002	
Analytes	Units	Value	2 x sig (1)	Value	2 x sig (1)
Gross Alpha	pCi/L	18 7	7 2	4 2	3 7
Gross Beta	pCi/L	5 7	6 5	4 0	5 8

(1) Two times the standard deviation for analysis

TABLE B-1 ROUND ONE COAGULATION/PRECIPITATION
FOR SUSPENDED SOLIDS

	INLET (1) SAMPLE	JAR NUMBER					
		1	2	3	4	5	6
Sample Number	11CPF1005	12CPF1001	12CPF1002	11CPF1003	11CPF1004		
Chemical Doses, mg/liter							
HCl - pH adjust		X	X	X	X		
NaOH - pH adjust							
Aluminum sulfate (2)							
Ferrous sulfate (2)							
Ferric sulfate (2)				15	25		
Ferric chloride (2)		15	25				
Nalco 8102 (3)							
Nalco 8182 (3)							
pH adjusted		6 0	6 0	6 0	6 0		
Flash Mix Speed, rpm		120	120	120	120		
Flash Mix Time, min		1	1	1	1		
Slow Mix Speed, rpm		40	40	40	40		
Slow Mix Time, min		20	20	20	20		
Settling Time, min		15	15	15	15		
Settling Rate, min (4)		7 5	7 5	never	never		
Turbidity	no	yes	yes	no	no		
Size Floc	none	small	small	none	none		
		~ 1 mm	~1 5 mm				
Temperature, C	17 0	18 5	18 5	18 5	18 5		
pH - final	7 2	6 2	6 0	6 2	6 2		
Analysis TSS, mg/liter	11	9	14	13	16		

(1) Surface water collected from location SW059 on 12 Nov 1990 sampled for TSS analysis 21 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE B-1 ROUND ONE COAGULATION/PRECIPITATION
FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
		1	2	3	4	5	6
Sample Number	11CPF1005	11CPF1007	11CPF1009	11CPF1010	11CPF1011	11CPF1012	11CPF1013
Chemical Doses, mg/liter							
HCl - pH adjust							
NaOH - pH adjust		X	X	X	X	X	X
Aluminum sulfate (2)							
Ferrous sulfate (2)		15	25	15	25	15	25
Ferric sulfate (2)							
Ferric chloride (2)							
Nalco 8102 (3)							
Nalco 8182 (3)							
pH adjusted		8 0	8 0	10 0	10 0	11 0	11 0
Flash Mix Speed, rpm		120	120	120	120	120	120
Flash Mix Time, min		1	1	1	1	1	1
Slow Mix Speed, rpm		40	40	40	40	40	40
Slow Mix Time, min		20	20	20	20	20	20
Settling Time, min		15	15	15	15	15	15
Settling Rate, min (4)		never	never	2	2	5	5
Turbidity	no	yes	yes	yes	yes	yes	yes
Size Floc	none	v small	small	small	small	large	large
		never	never	yellow	dark yellow	tan	yellow
		settled	settled	flocs	flocs	flocs	flocs
				(5)	(5)	(5)	(5)
Temperature, C	17 5	18 5	18 5	18 5	18 5	18 5	18 5
pH - final	7 2	7 6	7 5	9 6	9 6	10 7	10 7
Analysis TSS, mg/liter	11	22	23	10	9	16	184

(1) Surface water collected from location SW059 on 12 Nov 1990 sampled for TSS analysis 21 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE B-1 ROUND ONE COAGULATION/PRECIPITATION
FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
		1	2	3	4	5	6
Sample Number	11CPF1005	12CPF1014	12CPF1015	12CPF1016	12CPF1017	12CPF1018	12CPF1019
Chemical Doses, mg/liter							
HCl - pH adjust							
NaOH - pH adjust		X	X	X	X	X	X
Aluminum sulfate (2)							
Ferrous sulfate (2)							
Ferric sulfate (2)							
Ferric chloride (2)		15	25	15	25	15	25
Nalco 8102 (3)							
Nalco 8182 (3)							
pH adjusted		8 0	8 0	10 0	10 0	11 0	11 0
Flash Mix Speed, rpm		120	120	120	120	120	120
Flash Mix Time, min		1	1	1	1	1	1
Slow Mix Speed, rpm		40	40	40	40	40	40
Slow Mix Time, min		20	20	20	20	20	20
Settling Time, min		15	15	15	15	15	15
Settling Rate, min (4)		4	4	2	2	1 5	1 5
Turbidity	no	yes	yes	yes	yes	yes	yes
Size Floc	none	v small	v small	small	small	large	large
		orange	orange	orange	orange	white	white
		flocs	flocs	flocs	flocs	flocs	flocs
				(5)	(5)	(5)	(5)
Temperature, C	16	17 5	17 5	17 5	17 5	17 5	17 5
pH - final	7 2	7 8	7 7	9 9	9 8	10 6	10 6
Analysis TSS, mg/liter	11	<5	<5	6	<5	<5	<10

(1) Surface water collected from location SW059 on 12 Nov 1990 sampled for TSS analysis 21 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE B-1 ROUND ONE COAGULATION/PRECIPITATION
FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
		1	2	3	4	5	6
Sample Number	11CPF1005	13CPF1020	13CPF1021	13CPF1022	13CPF1023	13CPF1024	13CPF1025
Chemical Doses, mg/liter							
HCl - pH adjust		X	X				
NaOH - pH adjust				X	X	X	X
Aluminum sulfate (2)		15	25	15	25	15	25
Ferrous sulfate (2)							
Ferric sulfate (2)							
Ferric chloride (2)							
Nalco 8102 (3)							
Nalco 8182 (3)							
pH adjusted		6 0	6 0	8 0	8 0	10 0	10 0
Flash Mix Speed, rpm		120	120	120	120	120	120
Flash Mix Time, min		1	1	1	1	1	1
Slow Mix Speed, rpm		40	40	40	40	40	40
Slow Mix Time, min		20	20	20	20	20	20
Settling Time, min		15	15	15	15	15	15
Settling Rate, min (4)		never	never	never	never	1 0	0 5
Turbidity	no	clear	clear	clear	clear	(5)	(5)
Size Floc	none	none	none	none	none	small	fluffy
Temperature, C	18 5	20	20	20	20	20	20
pH - final	7 4	6 0	6 0	7 8	7 7	9 8	9 8
Analysis TSS, mg/liter	11	<5	<5	<5	7	<5	38

(1) Surface water collected from location SW059 on 12 Nov 1990 sampled for TSS analysis 21 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE B-1 ROUND ONE COAGULATION/PRECIPITATION FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
		1	2	3	4	5	6
Sample Number	14CPF1030	13CPF1026	13CPF1027	14CPF1028	14CPF1029	14CPF1031	14CPF1032
Chemical Doses, mg/liter							
HCl - pH adjust				X	X		
NaOH - pH adjust		X	X			X	X
Aluminum sulfate (2)		15	25				
Ferrous sulfate (2)							
Ferric sulfate (2)				15	25	15	25
Ferric chloride (2)							
Nalco 8102 (3)							
Nalco 8182 (3)							
pH adjusted		11 0	11 0	6 0	6 0	8 0	8 0
Flash Mix Speed, rpm		120	120	120	120	120	120
Flash Mix Time, min		1	1	1	1	1	1
Slow Mix Speed, rpm		40	40	40	40	40	40
Slow Mix Time, min		20	20	20	20	20	20
Settling Time, min		15	15	15	15	15	15
Settling Rate, min (4)		1 5	2 0	6 5	6 5	12 5	12 5
Turbidity	no	milky	milky	clear	clear	clear	clear
Size Floc	none	large	large	small	small	small	small
		white	white	yellow	yellow	yellow	yellow
		fluffy	fluffy	fluffy	fluffy	suspended	suspended
Temperature, C	17 0	18	18	18	18	18	18
pH - final	7 5	10 6	10 5	7 2	7 1	8 0	7 9
Analysis TSS, mg/liter	<5	66	80	7	6	7	6

(1) Surface water collected from location SW059 on 12 Nov 1990 sampled for TSS analysis 27 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE B-1 ROUND ONE COAGULATION/PRECIPITATION
FOR SUSPENDED SOLIDS (CONCLUDED)

	INLET (1) SAMPLE	JAR NUMBER					
		1	2	3	4	5	6
Sample Number	14CPF1030	14CPF1033	14CPF1034	14CPF1035	14CPF1036		
Chemical Doses, mg/liter							
HCl - pH adjust							
NaOH - pH adjust		X	X	X	X		
Aluminum sulfate (2)							
Ferrous sulfate (2)							
Ferric sulfate (2)		15	25	15	25		
Ferric chloride (2)							
Nalco 8102 (3)							
Nalco 8182 (3)							
pH adjusted		10 0	10 0	11 0	11 0		
Flash Mix Speed, rpm		120	120	120	120		
Flash Mix Time, min		1	1	1	1		
Slow Mix Speed, rpm		40	40	40	40		
Slow Mix Time, min		20	20	20	20		
Settling Time, min		15	15	15	15		
Settling Rate, min (4)		2	4	4	3		
Turbidity	no	milky	milky	milky	milky		
Size Floc	none	small	small	large	large		
				fluffy	fluffy		
Temperature, C	17 0	18	18	18	18		
pH - final	7 5	9 8	9 8	10 7	10 6		
Analysis TSS, mg/liter	<5	108	93	128	134		

(1) Surface water collected from location SW059 on 12 Nov 1990 sampled for TSS analysis 27 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE C-1 ROUND TWO COAGULATION/PRECIPITATION FOR SUSPENDED SOLIDS

	INLET (1) SAMPLE	JAR NUMBER					
		1	2	3	4	5	6
Sample Number	21CPF1001	21CPF1003	21CPF1005	21CPF1006	21CPF1007	21CPF1008	21CPF1009
Chemical Doses, mg/liter							
HCl - pH adjust							
NaOH - pH adjust							
Aluminum sulfate (2)					X	X	X
Ferrous sulfate (2)							
Ferric sulfate (2)		15	15	15	15	15	15
Ferric chloride (2)							
Nalco 8102 (3)							
Nalco 8182 (3)			1 0			1 0	
pH adjusted				0 5			0 5
Flash Mix Speed, rpm		No	No	No	8 0	8 0	8 0
Flash Mix Time, min		120	120	120	120	120	120
Slow Mix Speed, rpm		1	1	1	1	1	1
Slow Mix Time, min		40	40	40	40	40	40
Settling Time, min		20	20	20	20	20	20
Settling Rate, min (4)		15	15	15	15	15	15
Turbidity	no	none	none	none	never	never	never
Size Floc	none	milky	milky	milky	milky	milky	milky
		none	none	none	v small	v small	v small
Temperature, C	15 5	17 5	17 5	17 5	17 5	17 5	17 5
pH - final	7 7	7 7	7 7	7 7	7 9	7 9	7 9
Analysis TSS, mg/liter	7	17	18	21	20	21	28

(1) Surface water collected from location SW059 on 12 Nov 1990 sampled for TSS analysis 29 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE C-1 ROUND TWO COAGULATION/PRECIPITATION
FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
Sample Number	21CPF1001	1 22CPF1010	2 22CPF1011	3 22CPF1012	4 22CPF1013	5 22CPF1014	6 22CPF1015
Chemical Doses, mg/liter							
HCl - pH adjust							
NaOH - pH adjust							
Aluminum sulfate (2)					X	X	X
Ferrous sulfate (2)							
Ferric sulfate (2)							
Ferric chloride (2)							
Nalco 8102 (3)		15	15	15	15	15	15
Nalco 8182 (3)			1 0			1 0	1 0
pH adjusted				0 5			
Flash Mix Speed, rpm		No	No	No	8 0	8 0	10 0
Flash Mix Time, min		120	120	120	120	120	120
Slow Mix Speed, rpm		1	1	1	1	1	1
Slow Mix Time, min		40	40	40	40	40	40
Settling Time, min		20	20	20	20	20	20
Settling Rate, min (4)		15	15	15	15	15	15
Turbidity	no	8 clear	8 clear	8 clear	8 clear	8 clear	2 (5)
Size Floc	none	small	small	small	small	small	small
Temperature, C	17	18 5	18 5	18 5	18 5	18 5	18 5
pH - final	7 8	7 8	7 8	7 8	7 7	7 7	9 8
Analysis TSS, mg/liter	7	<5	6	<5	<5	<5	122

(1) Surface water collected from location SW059 on 12 Nov 1990 sampled for TSS analysis 29 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE C-1 ROUND TWO COAGULATION/PRECIPITATION FOR SUSPENDED SOLIDS (CONCLUDED)

	INLET (1) SAMPLE	JAR NUMBER					
		1	2	3	4	5	6
Sample Number	24CPF1016	24CPF1017	24CPF1018	24CPF1019	24CPF1020	24CPF1021	24CPF1022
Chemical Doses, mg/liter							
HCl - pH adjust							
NaOH - pH adjust							
Aluminum sulfate (2)					X	X	X
Ferrous sulfate (2)							
Ferric sulfate (2)							
Ferric chloride (2)		15	15	15	15	15	15
Nalco 8102 (3)							
Nalco 8182 (3)			1 0			1 0	1 0
pH adjusted				0 5			
Flash Mix Speed, rpm		No	No	No	8 0	8 0	10 0
Flash Mix Time, min		120	120	120	120	120	120
Slow Mix Speed, rpm		1	1	1	1	1	1
Slow Mix Time, min		40	40	40	40	40	40
Settling Time, min		20	20	20	20	20	20
Settling Rate, min (4)		15	15	15	15	15	15
Turbidity	no	8	8	8	14	8	2
Size Floc	none	clear	clear	clear	clear	clear	(5)
		small	small	small	v small	v small	medium
		suspended	suspended	suspended	suspended	suspended	
Temperature, C	16	18	18	18	18	18	18
pH - final	7 4	7 4	7 4	7 4	7 8	7 8	9 8
Analysis TSS, mg/liter	<5	6	<5	<5	<5	<5	90

(1) Surface water collected from location SW059 on 26 Nov 1990 sampled for TSS analysis 30 Nov 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1% wt
(4) Time required for bulk of particles to settle
(5) Considerable ppt formed during pH adjustment

TABLE D-1 ROUND THREE COAGULATION/PRECIPITATION/FILTRATION FOR SUSPENDED SOLIDS

	INLET (1) SAMPLE	JAR NUMBER					
		1		2		3	
Sample Number	30CPF1001	30CPF1002	30CPF1003	30CPF1004	30CPF1005	30CPF1006	30CPF1007
Chemical Doses, mg/liter							
NaOH - pH adjust							
Ferric chloride (2)							
Ferric sulfate (2)							
Nalco 8102 (3)				1 0			
Nalco 8182 (3)						0 5	
pH adjusted		No		No		No	
Flash Mix Speed, rpm		120		120		120	
Flash Mix Time, min		1		1		1	
Slow Mix Speed, rpm		40		40		40	
Slow Mix Time, min		20		20		20	
Settling Time, min		15		15		15	
Settling Rate, min (4)		never		never		never	
Turbidity	no	clear		clear		clear	
Size Floc	none	none		none		none	
Temperature, C	15	16		16		16	
pH - final	7 2	7 4		7 4		7 5	
Filter - ml/min			40		44		46
time, min			63		61		59
Analysis TSS, mg/liter	<3 3						
Prefiltered		<3 3		<3 3		<3 3	
Postfiltered			<3 3		<3 3		<3 3

(1) Surface water collected from location SW059 on 5 dec 1990 sampled for TSS analysis 7 Dec 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1%
(4) Time required for bulk of particles to settle

TABLE D-1 ROUND THREE COAGULATION/PRECIPITATION/FILTRATION FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
		1		2		3	
Sample Number	32CPF1018	32CPF1008	32CPF1009	32CPF2010	32CPF2011	32CPF1012	32CPF1013
Chemical Doses, mg/liter							
NaOH - pH adjust							
Ferric chloride (2)		15		15		15	
Ferric sulfate (2)							
Nalco 8102 (3)						1 0	
Nalco 8182 (3)							
pH adjusted		No		No		No	
Flash Mix Speed, rpm		120		120		120	
Flash Mix Time, min		1		1		1	
Slow Mix Speed, rpm		40		40		40	
Slow Mix Time, min		20		20		20	
Settling Time, min		15		15		15	
Settling Rate, min (4)		never		never		never	
Turbidity	no	clear		clear		clear	
Size Floc	none	none		none		none	
Temperature, C	18 5	19		19		19	
pH - final	7 2	7 2		7 3		7 3	
Filter - ml/min			41		49		44
time, min			61		59		61
Analysis TSS, mg/liter	3 7						
Prefiltered		<3 3		<3 3		<3 3	
Postfiltered			<3 3		<3 3		<3 3

(1) Surface water collected from location SW059 on 5 Dec 1990 sampled for TSS analysis 10 Dec 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1%
(4) Time required for bulk of particles to settle

TABLE D-1 ROUND THREE COAGULATION/PRECIPITATION/FILTRATION FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
		1		2		3	
Sample Number	32CPF1018	32CPF1014	32CPF1015	32CPF1016	32CPF1017	32CPF1019	32CPF1020
Chemical Doses, mg/liter							
NaOH - pH adjust						X	
Ferric chloride (2)		15		15		15	
Ferric sulfate (2)							
Nalco 8102 (3)		2 0					
Nalco 8182 (3)				0 5			
pH adjusted		No		No		8 0	
Flash Mix Speed, rpm		120		120		120	
Flash Mix Time, min		1		1		1	
Slow Mix Speed, rpm		40		40		40	
Slow Mix Time, min		20		20		20	
Settling Time, min		15		15		15	
Settling Rate, min (4)		never		never		never	
Turbidity	no	clear		clear		clear	
Size Floc	none	none		none		none	
Temperature, C	18	19		19		19	
pH - final	7 3	7 5		7 5		7 5	
Filter - ml/min			42		42		42
time, min			63		64		65
Analysis TSS, mg/liter	3 7						
Prefiltered		10		5 5		3 7	
Postfiltered			<3 3		<3 3		<3 3

(1) Surface water collected from location SW059 on 5 Dec 1990 sampled for TSS analysis 10 Dec 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1%
(4) Time required for bulk of particles to settle

TABLE D-1 ROUND THREE COAGULATION/PRECIPITATION/FILTRATION FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
		1		2		3	
Sample Number	32CPF1018	32CPF1021	32CPF1022	32CPF1023	32CPF1024	32CPF1025	32CPF1026
Chemical Doses, mg/liter							
NaOH - pH adjust		X		X			
Ferric chloride (2)		15		15			
Ferric sulfate (2)						15	
Nalco 8102 (3)		1 0					
Nalco 8182 (3)				0 5			
pH adjusted		8 0		8 0		No	
Flash Mix Speed, rpm		120		120		120	
Flash Mix Time, min		1		1		1	
Slow Mix Speed, rpm		40		40		40	
Slow Mix Time, min		20		20		20	
Settling Time, min		15		15		15	
Settling Rate, min (4)		never		never		never	
Turbidity	no	clear		clear		clear	
Size Floc	none	none		none		none	
Temperature, C	19	19		19		19	
pH - final	7 2	7 9		8 0		7 4	
Filter - ml/min			32		32		40
time, min			70		73		64
Analysis TSS, mg/liter	3 7						
Prefiltered		5 5		11		5 0	
Postfiltered			3 3		4 3		<3 3

(1) Surface water collected from location SW059 on 5 Dec 1990 sampled for TSS analysis 10 Dec 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1%
(4) Time required for bulk of particles to settle

TABLE D-1 ROUND THREE COAGULATION/PRECIPITATION/FILTRATION FOR SUSPENDED SOLIDS (CONTINUED)

	INLET (1) SAMPLE	JAR NUMBER					
		1		2		3	
Sample Number	32CPF1018	34CPF1027	34CPF1028	34CPF1029	34CPF1030	34CPF1031	34CPF1032
Chemical Doses, mg/liter							
NaOH - pH adjust							
Ferric chloride (2)							
Ferric sulfate (2)		15		15		15	
Nalco 8102 (3)		1 0		2 0			
Nalco 8182 (3)						0 5	
pH adjusted		No		No		No	
Flash Mix Speed, rpm		120		120		120	
Flash Mix Time, min		1		1		1	
Slow Mix Speed, rpm		40		40		40	
Slow Mix Time, min		20		20		20	
Settling Time, min		15		15		15	
Settling Rate, min (4)		never		never		never	
Turbidity	no	clear		clear		clear	
Size Floc	none	none		none		none	
Temperature, C	18	19		19		19	
pH - final	7 1	7 2		7 2		7 2	
Filter - ml/min			33		31		36
time, min			73		83		66
Analysis TSS, mg/liter	3 7						
Prefiltered		7 5		6 7		6 5	
Postfiltered			<3 3		<3 3		3 3

(1) Surface water collected from location SW059 on 5 Dec 1990 sampled for TSS analysis 10 Dec 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1%
(4) Time required for bulk of particles to settle

TABLE D-1 ROUND THREE COAGULATION/PRECIPITATION/FILTRATION FOR SUSPENDED SOLIDS (CONCLUDED)

	INLET (1) SAMPLE	JAR NUMBER					
		1		2		3	
Sample Number	32CPF1018	34CPF1033	34CPF1034	34CPF1035	34CPF1036	34CPF1037	34CPF1038
Chemical Doses, mg/liter							
NaOH - pH adjust		X		X		X	
Ferric chloride (2)							
Ferric sulfate (2)		15		15		15	
Nalco 8102 (3)				1 0		2 0	
Nalco 8182 (3)							
pH adjusted		8 0		8 0		8 0	
Flash Mix Speed, rpm		120		120		120	
Flash Mix Time, min		1		1		1	
Slow Mix Speed, rpm		40		40		40	
Slow Mix Time, min		20		20		20	
Settling Time, min		15		15		15	
Settling Rate, min (4)		never		never		never	
Turbidity	no	clear		clear		clear	
Size Floc	none	none		none		none	
Temperature, C	18 5	19 5		19 5		19 5	
pH - final	7 2	8 0		8 1		8 1	
Filter - ml/min			37		36		41
time, min			78		81		72
Analysis TSS, mg/liter	3 7						
Prefiltered		8 5		7 5		8 5	
Postfiltered			8 0		4 0		5 0

(1) Surface water collected from location SW059 on 5 Dec 1990 sampled for TSS analysis 10 Dec 1990
(2) Coagulant stock solution, 5 mg/ml
(3) Flocculant stock solution, 0 1%
(4) Time required for bulk of particles to settle

TABLE D-2 ROUND THREE COAGULATION/PRECIPITATION/FILTRATION FOR SUSPENDED SOLIDS
RESULTS OF ANALYSIS FOR WATER QUALITY PARAMETERS

Sample Number	Coagulant	Amount mg/L	pH	Polymer Type	Polymer Amt, ppm	Pre/Post Filtration	Chloride mg/L	Carbonate g CaCO3/L	Fluoride mg/L	Nitrate +Nitrite mg N/L	pH	Sulfate mg/L	Specific Conductance umhos/cm	TDS mg/L	TSS mg/L
30CPF1001	-	-	-	-	-	Inlet	56 4	380	1 0	3 78	7 58	50 6	960	605	<3 3
30CPF1002	none	-	unadj	none	-	pre	56 5	396	1 1	3 79	7 59	54 2	949	585	<3 3
30CPF1003	none	-	unadj	none	-	post	56 9	394	1 1	3 77	7 82	51 2	954	580	<3 3
30CPF1004	none	-	unadj	#8102	1 0	pre	56 5	392	1 0	3 85	7 62	38 4	960	590	<3 3
30CPF1005	none	-	unadj	#8102	1 0	post	56 7	386	1 0	3 85	7 93	41 2	949	590	<3 3
30CPF1006	none	-	unadj	#8182	0 5	pre	56 5	386	1 0	3 79	7 51	58 8	954	515	<3 3
30CPF1007	none	-	unadj	#8182	0 5	post	56 4	384	<1 0	3 53	7 61	62 4	954	510	<3 3
32CPF1008	Ferric Chloride	15	unadj	none	-	pre	58 3	370	1 0	3 71	7 41	49 8	960	550	<3 3
32CPF1009	Ferric Chloride	15	unadj	none	-	post	58 6	366	<1 0	3 83	7 92	44 8	960	545	<3 3
32CPF2010	Ferric Chloride	15	unadj	none	-	pre	58 3	376	1 0	3 76	7 52	48 0	960	555	<3 3
32CPF2011	Ferric Chloride	15	unadj	none	-	post	58 3	362	<1 0	3 81	7 83	39 0	954	555	<3 3
32CPF1012	Ferric Chloride	15	unadj	#8102	1 0	pre	58 1	386	<1 0	3 83	7 49	40 2	960	520	<3 3
32CPF1013	Ferric Chloride	15	unadj	#8102	1 0	post	58 8	376	<1 0	3 75	7 90	40 2	960	555	<3 3
32CPF1014	Ferric Chloride	15	unadj	#8102	2 0	pre	58 5	378	<1 0	3 80	7 64	40 8	954	525	10 0
32CPF1015	Ferric Chloride	15	unadj	#8102	2 0	post	58 5	382	<1 0	3 81	7 84	40 8	960	535	<3 3
32CPF1016	Ferric Chloride	15	unadj	#8182	0 5	pre	58 6	390	<1 0	3 79	7 69	48 4	960	560	5 5
32CPF1017	Ferric Chloride	15	unadj	#8182	0 5	post	58 4	382	<1 0	3 59	7 89	39 8	949	545	<3 3
32CPF1018	-	-	-	-	-	Inlet	59 5	374	<1 0	3 72	7 62	48 0	949	560	3 7
32CPF1019	Ferric Chloride	15	8	none	-	pre	62 5	422	<1 0	3 72	7 97	45 6	960	555	3 7
32CPF1020	Ferric Chloride	15	8	none	-	post	62 5	422	<1 0	3 71	8 17	46 2	954	610	<3 3
32CPF1021	Ferric Chloride	15	8	#8102	1 0	pre	61 5	428	1 0	3 76	7 91	42 4	1010	580	5 5
32CPF1022	Ferric Chloride	15	8	#8102	1 0	post	<5 0	424	<1 0	3 29	7 98	40 8	954	600	3 3
32CPF1023	Ferric Chloride	15	8	#8182	0 5	pre	61 7	438	1 0	3 71	8 02	43 4	949	625	11 0
32CPF1024	Ferric Chloride	15	8	#8182	0 5	post	61 6	416	<1 0	3 73	7 89	43 8	926	635	4 3
32CPF1025	Ferric Sulfate	15	unadj	none	-	pre	59 4	380	1 0	3 58	7 62	52 4	960	575	5 0
32CPF1026	Ferric Sulfate	15	unadj	none	-	post	59 6	386	<1 0	3 65	7 90	55 6	960	580	<3 3
34CPF1027	Ferric Sulfate	15	unadj	#8102	1 0	pre	59 6	380	<1 0	3 63	7 51	45 2	960	590	7 5
34CPF1028	Ferric Sulfate	15	unadj	#8102	1 0	post	62 4	382	<1 0	3 65	7 82	50 6	960	620	<3 3
34CPF1029	Ferric Sulfate	15	unadj	#8102	2 0	pre	59 7	378	<1 0	3 76	7 34	44 4	960	580	6 7
34CPF1030	Ferric Sulfate	15	unadj	#8102	2 0	post	59 5	388	1 0	3 66	8 00	42 8	937	600	<3 3
34CPF1031	Ferric Sulfate	15	unadj	#8182	0 5	pre	59 8	382	1 0	3 66	7 62	51 2	954	610	6 5
34CPF1032	Ferric Sulfate	15	unadj	#8182	0 5	post	59 9	390	1 0	3 69	7 91	49 3	949	605	3 3
34CPF1033	Ferric Sulfate	15	8	none	-	pre	60 0	420	<1 0	3 73	8 09	53 0	1020	640	8 5
34CPF1034	Ferric Sulfate	15	8	none	-	post	60 2	412	<1 0	3 67	7 96	51 6	960	660	8 0
34CPF1035	Ferric Sulfate	15	8	#8102	1 0	pre	60 3	428	1 0	3 60	8 07	42 4	982	635	7 5
34CPF1036	Ferric Sulfate	15	8	#8102	1 0	post	60 2	398	<1 0	3 67	7 81	43 8	925	630	4 0
34CPF1037	Ferric Sulfate	15	8	#8102	2 0	pre	60 1	438	<1 0	3 64	8 01	42 0	1020	640	8 5
34CPF1038	Ferric Sulfate	15	8	#8102	2 0	post	59 8	420	1 0	3 68	7 89	46 0	937	640	5 0

Note Shaded entries are results for inlet sample before any pH adjustment or coagulant/polymer addition

TABLE D-3 ROUND THREE COAGULATION/PRECIPITATION/FILTRATION FOR SUSPENDED SOLIDS RESULTS FOR ANALYSIS OF METALS

Sample Number	Coagulant	Amt g/L	pH	Polymer Type	Polymer ppm	Pre/Post Filtration	Al ug/L	As g/L	Ba ug/L	Cd g/L	Ca ug/L	Cr ug/L	Cu ug/L	Fe ug/L	Pb ug/L	Mg ug/L	Mn ug/L	Ni ug/L	K ug/L	Na ug/L	Tl ug/L	V g/L	Zn ug/L
30CPF1001	-	-	-	-	-	Inlet	<20	2 5	231	<1	131000	<4	1 2	21 3	2 7	33400	12 8	<4	2130	38800	3 J	<3	325
30CPF1002	none	-	unadj	none	-	pre	<20	<2	231	<1	130000	<4	<1	21 3	2 5	33200	12 8	<4	2070	38600	3 J	<3	334
30CPF1003	none	-	unadj	none	-	post	<20	2 2	226	<1	129000	<4	3 7	19 6	1 6	32700	13 3	<4	2060	38000	3 J	5 0	308
30CPF1004	none	-	unadj	#8102	1 0	pre	114 0	<2	232	<1	132000	<4	2 5	349 0	3 0	33500	13 8	<4	2050	39000	3 J	5 5	327
30CPF1005	none	-	unadj	#8102	1 0	post	25 7	<2	244	2 0	141000	<4	1 2	17 9	4 7	35400	14 1	<4	2210	41000	3 J	4 4	332
30CPF1006	none	-	unadj	#8182	0 5	pre	<20	2 3	231	<1	132000	<4	<1	35 4	3 6	33200	12 5	<4	2130	38200	3 J	3 9	338
30CPF1007	none	-	unadj	#8182	0 5	post	46 0	2 5	231	<1	133000	<4	1 2	57 1	3 2	33500	14 1	<4	2170	38600	3 J	3 3	318
32CPF1008	Ferric Chloride	15	unadj	none	_	pre	29 1	<2	229	<1	131000	4 5	11 3	1350 J	6 7	33200	17 1	<4	2100	38200	3 J	4 3	324
32CPF1009	Ferric Chloride	15	unadj	none	_	post	21 3	<2	227	<1	133000	<4	1 8	20 8	3 0	33500	17 6	<4	2180	38600	3 J	4 4	291
32CPF2010	Ferric Chloride	15	unadj	none	_	pre	99 6	2 1	225	<1	128000	<4	<1	1040 J	3 8	32600	17 1	<4	2540	37600	3 J	<3	330
32CPF2011	Ferric Chloride	15	unadj	none	_	post	<20	<2	219	<1	126000	<4	3 1	20 8	2 1	32400	16 9	<4	2150	37300	3 J	<3	276
32CPF1012	Ferric Chloride	15	unadj	#8102	1 0	pre	<20	<2	224	<1	127000	<4	1 3	1020 0	3 7	32600	16 4	<4	2060	37700	3 J	<3	307
32CPF1013	Ferric Chloride	15	unadj	#8102	1 0	post	30 1	<2	214	1 1	123000	<4	2 5	20 0	54 1	31800	16 6	<4	2230	36800	3 J	<3	256
32CPF1014	Ferric Chloride	15	unadj	#8102	2 0	pre	57 8	<2	227	<1	128000	<4	10 6	1080 0	1 9	33100	17 4	<4	2170	38600	3 J	<3	326
32CPF1015	Ferric Chloride	15	unadj	#8102	2 0	post	33 0	<2	225	<1	129000	<4	1 8	18 8	40 7	33300	16 6	<4	2150	38700	3 J	<3	236
32CPF1016	Ferric Chloride	15	unadj	#8182	0 5	pre	<20	<2	224	<1	127000	<4	3 2	1040 0	4 0	32600	16 9	<4	2120	37800	3 J	<3	309
32CPF1017	Ferric Chloride	15	unadj	#8182	0 5	post	<20	<2	224	<1	130000	<4	<1	<17	4 5	33100	16 9	<4	2100	38400	3 J	<3	244
32CPF1018	-	-	-	-	-	Inlet	32 5	<2	215	<1	126000	<4	1 9	37 1	1.7	32100	7 9	<4	1780	40700	3 J	<3	290
32CPF1019	Ferric Chloride	15	8	none	-	pre	<20	<2	219	<1	129000	<4	1 0	989 0	1 7	32800	13 0	<4	2840	59400	3 J	<3	317
32CPF1020	Ferric Chloride	15	8	none	-	post	150 0	3 6	205	<1	115000	<4	6 8	252 J	3 6 J	30500	12 1	<4	2710	57400	<2	<3	154
32CPF1021	Ferric Chloride	15	8	#8102	1 0	pre	96 8	<3	203	<1	111000	<4	6 9	1070 J	2 4 J	29600	10 8	<4	1660	59300	10	<3	264
32CPF1022	Ferric Chloride	15	8	#8102	1 0	post	27 7	<3	200	<1	111000	<4	6 8	23 8 J	2 3	29900	10 3	<4	1740	59900	10	<3	129
32CPF1023	Ferric Chloride	15	8	#8182	0 5	pre	23 0	<3	204	<1	112000	<4	6 9	904 J	4 0	29800	10 8	<4	1570	60300	10	<3	267
32CPF1024	Ferric Chloride	15	8	#8182	0 5	post	<20	<3	207	<1	115000	<4	4 1	17 J	2 4	30700	10 8	<4	1690	62400	10	<3	138
32CPF1025	Ferric Sulfate	15	unadj	none	-	pre	104 0	<3	210	<1	115000	21 7	6 2	925 J	2 9	30700	10 8	11 4	1710	40000	<2	<3	277
32CPF1026	Ferric Sulfate	15	unadj	none	-	post	92 6	3 3	208	<1	116000	<4	6 8	76 J	2 1	30800	8 9	<4	1730	40400	<2	<3	284
34CPF1027	Ferric Sulfate	15	unadj	#8102	1 0	pre	70 1	<3	214	<1	118000	<4	11 6	842 J	1 5	31200	8 1	<4	1660	41000	<2	<3	278
34CPF1028	Ferric Sulfate	15	unadj	#8102	1 0	post	<20	<3	202	<1	113000	<4	11 5	37 6 J	3 4	30100	8 6	<4	4250	39200	<2	<3	283
34CPF1029	Ferric Sulfate	15	unadj	#8102	2 0	pre	22 5	<3	210	<1	115000	<4	7 5	806 J	2 9	30600	8 1	<4	1620	40000	<2	<3	274
34CPF1030	Ferric Sulfate	15	unadj	#8102	2 0	post	30 3	<3	205	<1	115000	<4	10 2	27 3 J	1 6	30500	8 6	<4	1800	39800	<2	<3	299
34CPF1031	Ferric Sulfate	15	unadj	#8182	0 5	pre	21 4	<3	206	<1	114000	<4	9 6	764 J	1 4	30400	8 4	<4	1640	39700	<2	<3	272
34CPF1032	Ferric Sulfate	15	unadj	#8182	0 5	post	31 9	<3	210	<1	117000	<4	21 0	21 4 J	3 1	31100	8 9	<4	2880	40700	<2	<3	264
34CPF1033	Ferric Sulfate	15	8	none	-	pre	23 0	<3	210	<1	115000	<4	6 8	804 J	3 0	30700	8 9	<4	1960	63200	10	<3	281
34CPF1034	Ferric Sulfate	15	8	none	-	post	29 8	<3	203	<1	115000	4 1	6 8	22 2 J	2 8	30600	8 9	<4	2050	62900	10	<3	101
34CPF1035	Ferric Sulfate	15	8	#8102	1 0	pre	33 5	<3	210	<1	116000	<4	11 6	801 J	5 1	30700	9 1	<4	1830	59700	<2	<3	275
34CPF1036	Ferric Sulfate	15	8	#8102	1 0	post	32 4	<3	201	<1	116000	<4	2 7	26 5 J	2 8	30600	8 4	<4	1830	59400	10	<3	95
34CPF1037	Ferric Sulfate	15	8	#8102	2 0	pre	24 6	<3	208	<1	117000	<4	1 4	764 0	2 8	30800	8 6	<4	1700	60800	<2	<3	284
34CPF1038	Ferric Sulfate	15	8	#8102	2 0	post	56 0	<3	204	<1	117000	<4	<1	64 2	2 4	31100	8 4	<4	2130	61400	<2	<3	110

Notes Shaded entries are results for inlet samples before any pH adjustment or coagulant/polymer addition

J Quantitification is estimated based on quality control checks

The following metals were not detected in any samples, detection limits in ug/L are in () Sb (17), Be (1), Co (2), Hg (0 2), Se (4), Ag (2)

TABLE E-1 SUMMARY OF DATA FROM ROUND 1 TESTS FOR VOC REMOVAL USING GRANULAR ACTIVATED CARBON

GAC Manuf	GAC Type	GAC Weight g	Feed Rate ml/min	Run Duration min	Volume Treated ml	Gas Chromatograph Results Peak Area Inlet	Gas Chromatograph Results Peak Area Outlet	Removal Efficiency
Yakima	CYP 12x40 mesh	75	10	240	2400	5 57E+08	0 00E+00	100 0%
Yakima	C-C 12x40 mesh	75	10	240	2400	5 57E+08	0 00E+00	100 0%
Calgon	F300 8x30 mesh	75	10	240	2400	5 57E+08	0 00E+00	100 0%
Norit	HD4000 12x40 mesh	75	10	240	2400	5 57E+08	0 00E+00	100 0%
Calgon	F400 12x40 mesh	75	10	240	2400	5 57E+08	0 00E+00	100 0%

Note Tests were run using surface water collected from location SW059 on November 6, 1990

TABLE E-2 ROUND 1 GRANULAR ACTIVATED CARBON FOR VOC REMOVAL

Sample Description	Sample Number	TOC as 11DCE (ug/l)
Inlet Water	01GAO1001	407 4
Effluent Yakima CYP	01GAO1002	0 0
Effluent Yakima C-C	01GAO1003	0 0
Effluent Calgon F 300	01GAO1004	0 0
Effluent Norit HD 4000	01GAO1005	0 0
Effluent Calgon F 400	01GAO1006	0 0

TABLE F-2 ROUND 2 GRANULAR ACTIVATED CARBON FOR VOC REMOVAL RESULTS FOR ANALYSIS OF VOLATILE ORGANIC COMPOUNDS

Sample Description		Inlet Water	Yakima CYP Effluent	Yakima CYP Effluent (Dup)	Yakima C-C Effluent	Calgon F 300 Effluent	Norit HD 4000 Effluent	Calgon F 300 Effluent
Sample Number		21GAO1004	21GAO1006	21GAO2007	22GAO1009	23GAO1010	24GAO1011	25GAO1012
Analytes	Units							
Chloromethane	ug/L	<10	<10	<10	<10	<10	<10	<10
Bromomethane	ug/L	<10	<10	<10	<10	<10	<10	<10
Vinyl Chloride	ug/L	<10	<10	<10	<10	<10	<10	<10
Chloroethane	ug/L	<10	<10	<10	<10	<10	<10	<10
Methylene Chloride	ug/L	<5	<5	<5	<5	<5	<5	<5
Acetone	ug/L	<100	<100	<100	<100	<100	<100	<100
Carbon Disulfide	ug/L	<5	<5	<5	<5	<5	<5	<5
1,1-Dichloroethene	ug/L	4 2 *	<5	<5	<5	<5	<5	<5
1,1-Dichloroethane	ug/L	3 7 *	<5	<5	<5	<5	<5	<5
1,2-Dichloroethenes, total	ug/L	97	<5	<5	<5	<5	<5	<5
Chloroform	ug/L	33	<5	<5	<5	<5	<5	<5
1 2-Dichloroethane	ug/L	<5	<5	<5	<5	<5	<5	<5
2-Butanone	ug/L	<100	<100	<100	<100	<100	<100	<100
1 1 1-Trichloroethane	ug/L	13	<5	<5	<5	<5	<5	<5
Carbon Tetrachloride	ug/L	140	<5	<5	<5	<5	<5	<5
Vinyl Acetate	ug/L	<50	<50	<50	<50	<50	<50	<50
Bromodichloromethane	ug/L	<5	<5	<5	<5	<5	<5	<5
1,2-Dichloropropane	ug/L	<5	<5	<5	<5	<5	<5	<5
trans-1,3-Dichloropropene	ug/L	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	ug/L	97	<5	<5	<5	<5	<5	<5
Dibromochloromethane	ug/L	<5	<5	<5	<5	<5	<5	<5
1,1,2-Trichloroethane	ug/L	<5	<5	<5	<5	<5	<5	<5
Benzene	ug/L	<5	<5	<5	<5	<5	<5	<5
cis-1 3-Dichloropropene	ug/L	<5	<5	<5	<5	<5	<5	<5
2-Choroethyl Vinyl Ether	ug/L	<10	<10	<10	<10	<10	<10	<10
Bromoform	ug/L	<5	<5	<5	<5	<5	<5	<5
4-Methyl-2-pentanone	ug/L	<50	<50	<50	<50	<50	<50	<50
2-Hexanone	ug/L	<50	<50	<50	<50	<50	<50	<50
Tetrachloroethene	ug/L	<5	<5	<5	<5	<5	<5	<5
1,1,2,2-Tetrachloroethane	ug/L	52	<5	<5	<5	<5	<5	<5
Toluene	ug/L	<5	<5	<5	<5	<5	<5	<5
Clorobenzene	ug/L	<5	<5	<5	<5	<5	<5	<5
Ethylbenzene	ug/L	<5	<5	<5	<5	<5	<5	<5
Styrene	ug/L	<5	<5	<5	<5	<5	<5	<5
Xylenes, total	ug/L	<5	<5	<5	<5	<5	<5	<5

* reported value is less than the reporting limit, quantitation may not be reliable

TABLE F-3 ROUND 2 GRANULAR ACTIVATED CARBON FOR VOC REMOVAL
RESULTS FOR ANALYSIS OF WATER QUALITY PARAMETERS

Sample Description		Inlet Water	Yakima CYP Effluent	Yakima CYP Effluent (Dup)	Yakima C-C Effluent	Calgon F 300 Effluent	Norit HD 4000 Effluent	Calgon F 300 Effluent
Sample Number		21GAO1004	21GAO1006	21GAO2007	22GAO1009	23GAO1010	24GAO1011	25GAO1012
Analytes	Units							
Chloride	mg/L	79 6	74	75	74	73 9	77 7	73 4
Carbonate	mg CaCO3/L	384	387	381	289	378	351	326
Fluoride	mg/L	<1 0	1 1	1 1	1 0	1 1	1 0	1 0
Nitrate plus Nitrite	mg N/L	1 53	<0 25	<0 25	0 33	0 4	<0 25	<0 25
pH	pH units	7 31	8 11	8 00	7 62	8 01	7 95	7 62
Sulfate	mg/L	51 6	37 1	36 2	35 3	44 3	56 1	39 4
Specific Conductance	umhos/cm	791	769	786	677	791	786	726
Total Dissolved Solids	mg/L	555	540	550	505	520	525	505
Total Suspended Solids	mg/L	<3 3	<3 3	<3 3	<3 3	<3 3	<3 3	<3 3

TABLE G-1 ROUND 3 GRANULAR ACTIVATED CARBON FOR VOC REMOVAL

Sample Identification	Sample Number	Elaspsed Time (hours)	Number of Bed Volumes	TOC as 1,1-DCE (ug/l)	Percent TOC of of Inlet Water
Inlet Water	31GAO1001	-	-	708 9	100
Effluent Calgon F 400	31GAO1002	15 17	379	5 2	0 7
Effluent Calgon F 400	31GAO1003	17 17	429	6 3	0 9
Effluent Calgon F 400	31GAO1004	19 17	479	6 4	0 9
Effluent Calgon F 400	31GAO1005	21 17	529	8 4	1 2
Effluent Calgon F 400	31GAO1006	23 00	575	8 4	1 2
Effluent Calgon F 400	31GAO1007	24 00	600	10 5	1 5

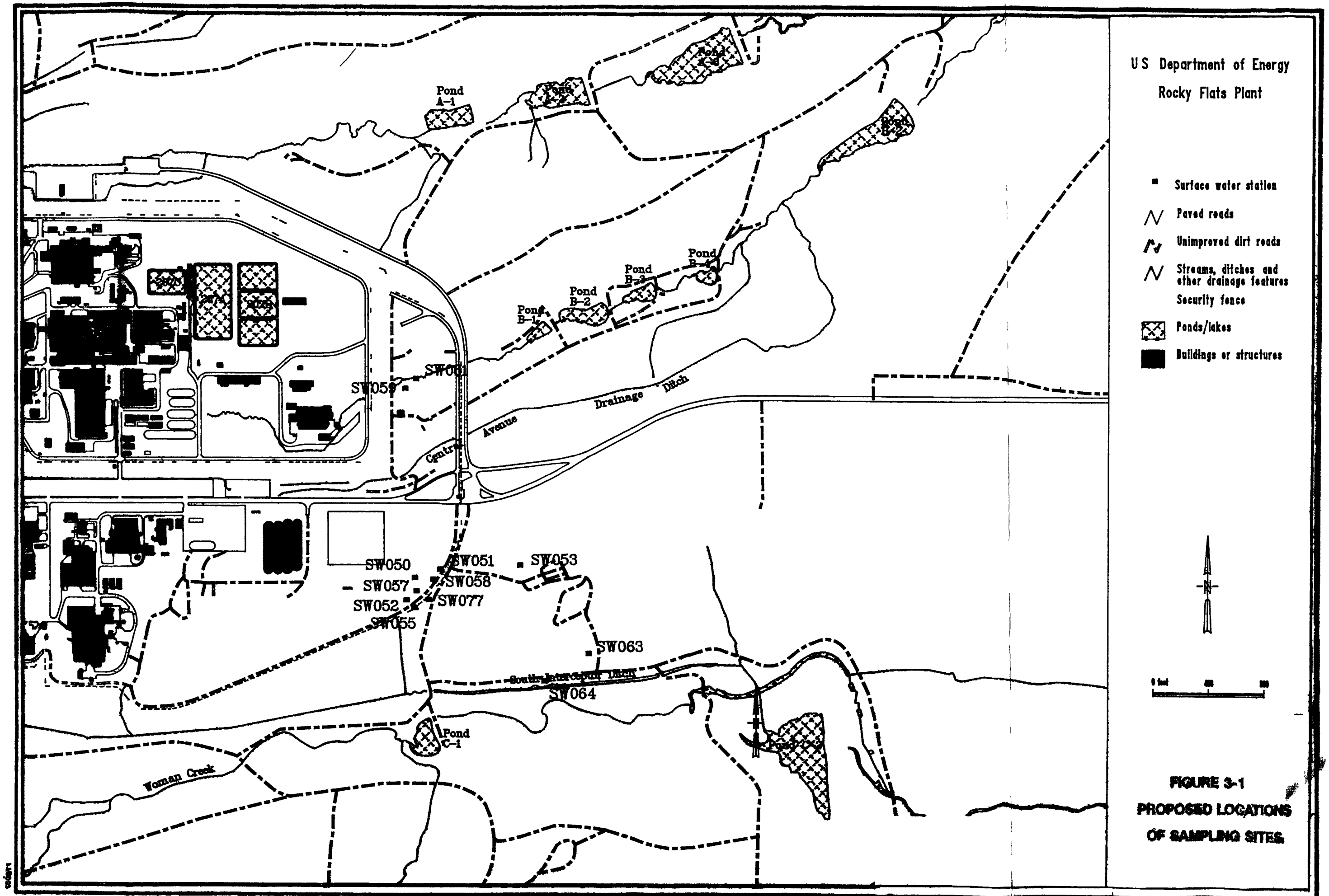

FIGURE 3-1
PROPOSED LOCATIONS
OF SAMPLING SITES